

Evaluation and Treatment of Smell Dysfunction

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We gave 63 patients with symptoms of smell dysfunction a full evaluation by age-adjusted olfactory threshold and odor identification testing, rhinomanometry, nasal cytology, nasal endoscopy, computed tomographic (CT) scan and a trial of medical treatment. CT scans were valuable for identifying ethmoid sinus disease and nasal endoscopy for inspecting olfactory epithelium. A trial of prednisone served as a diagnostic modality to identify correctable causes of smell dysfunction. Given that there are 2 million people in the United States with a smell dysfunction, that the average physician knows little about its diagnosis and treatment and that the psychosocial impact to an afflicted person is great, we urge a greater awareness of smell dysfunction, its diagnosis and its treatment.

(Davidson TM, Jalowayski A, Murphy C, et al: Evaluation and treatment of smell dysfunction. West J Med 1987 Apr; 146:434-438)

The first scent that fills the air after an early morning spring rain, the bouquet of a vintage cabernet sauvignon, the aroma of fresh coffee brewing and the distinctive scent of a loved one are a few of the odors that complement our daily lives and trigger both physiologic and psychologic reactions. The secretion of saliva and stomach juices is a well-known response to the odors of food passing through our nose. In their ads, perfume companies exploit the relationship between fragrance and emotion. A recent article in the *National Geographic* (B. Gibbons, "The Intimate Sense of Smell," 1986; 170:324-361) summarizes well the important role that olfaction plays, and extrapolation makes it clear that the absence of olfaction is a real disability.

The lack of smell has never been considered a major disability, yet it is, and it can have very distressing effects. Spoiled foods cannot be detected before ingestion. Gas leaks or the smell of smoke during a fire are not detected until the situation becomes catastrophic. Smell dysfunction can reduce the overall quality of a person's life, lead to increased stress and depression and be a danger to those with whom a person lives and works. Olfactory loss is neither a new nor a rare disease. The most recent estimates by the National Institutes of Health are that 2 million American adults suffer disorders of taste and smell.¹ Nevertheless, few physicians have the knowledge and experience to adequately evaluate smell and taste disorders. Part of the reason physicians lack knowledge of olfactory disturbances is that the nasal innervation and the subsequent encoding system are poorly understood. Consequently, few physicians learn about the pathologic processes or teach olfactory perception in medical school. The result is that few specialists are prepared to handle the task of evaluating patients with olfactory loss because this requires added personnel, time, resources and expense.

An understanding of chemosensory dysfunctions begins with a definition of terms. Anosmia refers to the absence of the sense of smell. Hyposmia refers to diminished sensitivity

to smell and dysosmia to a distortion of smell. Both phantosmia (smell of an odor for which there is no stimulus) and presbyosmia (hyposmia associated with aging) are important to remember. The absence of taste is termed ageusia, diminished sensitivity of taste is hypogeusia and dysgeusia is a distortion of taste.

It should be noted that among "normal persons" there is a wide range of olfactory acuity. Normal persons may have some degree of olfactory loss due to gender, smoking status or age. Women's olfactory acuity is superior to men's at all ages. Nonsmokers outperform smokers in olfactory testing. Doty showed that of persons older than 80 years, 80% evidenced major olfactory impairment with nearly 50% having anosmia.² Between 65 and 80 years of age, 60% had hyposmia and 25% anosmia.

A discussion of smell cannot exclude taste as they work together in the perception of flavor. Of the two senses, however, olfaction is by far the most important.

Anatomy and Physiology

For an odor to be perceived, a substance must fulfill two requirements: it must be volatile at ambient temperature, and it must be soluble in fat solvents. Once such a molecule reaches the receptors located in the pigmented upper portion of the superior nasal cavity, it binds to and depolarizes the olfactory nerve receptors. Schiffman and co-workers reported that there are about 1 million bipolar olfactory nerve cells, with a turnover of about 30 days. The bipolar cells are grouped in bundles that penetrate the cribriform plate of the ethmoid bone and course centrally in the olfactory bulb, where they synapse with secondary olfactory neurons. Here they form small bushy masses known as glomeruli. From the olfactory bulb, projections of secondary neurons course to the primitive cortex, hippocampal formation and the pyriform lobe. Any one of these anatomic locations can produce olfactory dysfunction.³

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Symptoms

Most patients who present with loss of smell report the change as a loss of taste, sometimes leading to a loss of appetite and weight loss, or, just as frequently, to increased food consumption and an associated weight gain. This seemingly paradoxical response is caused by a person eating more than normal in an attempt to "taste" what he or she is eating.

Most patients are seen initially by their primary physician and some are then referred to a head and neck surgeon. The patient initially disregards the changes, but ultimately seeks help as the disability persists and becomes an increasing annoyance. The absence of the usual pleasure of tasting foods becomes frustrating. Some patients may become the unfortunate victims of an explosion or fire resulting from their inability to detect leaking gas or smoke. Others are unable to detect rotten or spoiled food and may become the victims of food poisoning.

Patients and Materials

The Nasal Dysfunction Clinic at the University of California, San Diego, during the year 1985 fully evaluated 63 patients with a primary complaint of the loss of the sense of smell. The evaluation included a detailed history, age-adjusted olfactory threshold and odor identification testing, rhinomanometry, nasal cytology and nasal endoscopy. Following the initial evaluation, patients were prescribed corticosteroids applied by nasal spray (two sniffs each nostril twice a day), zinc sulfate (440 mg three times a day), prednisone (60 mg a day for four days, then tapering doses for three days) and, if any element of infection was present, erythromycin (250 mg four times a day for six weeks). A computed tomographic (CT) scan of the anterior cranial fossa, nasal cavity and paranasal sinuses was done. Where appropriate, a patient was referred for psychiatric evaluation. Results of the CT scan, response to medicines and results of all laboratory tests were then assessed at six weeks. A diagnosis was made and appropriate recommendations given.

The olfactory testing is crucial to this evaluation. We use olfactory threshold and odor identification testing as developed by Cain and colleagues.⁴ In a threshold task, patients seek to identify weak concentrations of the odorant *n*-butyl alcohol sniffed monorhinically from squeezable plastic bottles. The odorant is prepared in a series of dilutions beginning with 4% volume per volume in deionized water. Each of nine successive dilutions is a third the concentration of the preceding dilution. Two-alternative, forced-choice testing (alcohol solution versus a water blank) progresses from weaker to stronger concentrations. (Descending concentration series are generally avoided in olfactory threshold testing to minimize confounding by adaptation.) An incorrect choice, such as selection of the blank, leads to increased concentration on the next trial. Correct choices lead to presentation of the same concentration, to a criterion of four correct choices in a row. Two threshold determinations are made, one for each nostril.

The odor identification test consists of ten common odors, presented in random order, in small jars held under the nostrils. Patients close their eyes, sniff for about five seconds and then inspect the cue sheet provided. The cue sheet contains all ten odor names and ten distractor items. Testing proceeds from the right to left nostril until all items are presented once to each nostril. The patient is encouraged to guess when unsure and is provided with feedback about performance.

The maximum threshold score for each nostril is 50. Similarly, the maximum identification score for each nostril is 50. By summing the scores, an index of the patient's olfactory function is determined for each nostril. A score of 90 or 100 is considered normal, 60 to 80 mild hyposmia 40 to 60 moderate hyposmia, 20 to 40 severe hyposmia and 0 to 10 anosmia.

Results

The best information can be gleaned from these data if reviewed by diagnostic category. The seven diagnostic categories are listed in Table 1. Olfaction was measured as described above. The response to steroid therapy was recorded as positive if a patient reported an early improvement in his or her sense of smell. Unless other specific therapy was instituted, the improvement on a steroid regimen was invariably transitory and served primarily as a diagnostic confirmation that the person had the potential to smell. For this study the CT scans were interpreted as normal or abnormal. The olfactory epithelium or superior nasal cavity (or both), if seen, yielded important diagnostic information. Rhinomanometry and nasal cytology were useful in confirming the diagnoses of nasal obstruction, infection and allergy. Interpretation of these tests is complex and is therefore reported in a separate publication.

Inflammatory Dysfunction

Inflammatory disorders included infectious and allergic disease, and this category comprised the greatest number of patients. The test results are summarized in Table 2. Important observations are that men exceed women 2 to 1. Mean olfactory scores indicated severe hyposmia. These patients were unable to "taste" their foods and were unable to smell smoke, gas or spoiled food. Of 17 patients who took a one-week course of steroids, 100% noted some improvement in their ability to smell. Of the 13 patients who had a CT scan, 100% showed paranasal sinus disease. The single most important findings were mucosal thickening, air-fluid levels or opacification of the ethmoid sinuses.

TABLE 1.—63 Patients With Smell Dysfunction

Diagnostic Category	Patients, Number	%
Inflammatory	21	33
Postviral	20	32
Trauma	6	10
Toxins	7	11
Congenital	3	5
Miscellaneous	3	5
Psychiatric	3	5
Total	63	101

TABLE 2.—Clinical Features of 21 Patients With Inflammatory Dysfunction

Age, yr	Mean 51; SD±12; range 27-74
Male/female ratio	14/7
Olfactory scores	
Right nostril	Mean 31±32 (1 SD); range 0-90
Left nostril	Mean 33±33 (1 SD); range 0-100
Response to steroids	Improved 17; not improved 0
CT scan findings	Abnormal 13; normal 0

CT=computed tomographic, SD=standard deviation

Viral Dysfunction

Findings in patients who lost their sense of smell after a viral illness are summarized in Table 3. Pertinent data included a male-to-female ratio of 1 to 4. Olfactory scores indicated severe hyposmia. Two patients noted an improved sense of smell on prednisone therapy and nine did not. One had an abnormal CT scan, and nine had a normal CT scan.

Traumatic Dysfunction

Findings associated with trauma-induced smell dysfunction are summarized in Table 4. Most patients were young men. Olfactory scores indicated anosmia in four patients and hyposmia in two. No improvement was noted with prednisone therapy, nor were abnormalities present on CT scans.

Toxin Dysfunction

Seven patients lost their sense of smell from toxin exposure. Relevant data appear in Table 5. The toxins responsible were ammonia (three cases), photodeveloping chemicals, hair dressing chemicals, liquid propane and a combination of acetone and cigar use, one case each. Olfactory scores indicated severe hyposmia. No patients responded favorably to the administration of corticosteroids, and none had abnormalities on a CT scan.

Congenital Dysfunction

Three patients were evaluated with congenital anosmia. All three scored 0 points on olfactory testing.

Miscellaneous Dysfunction

Three cases were categorized under miscellaneous dysfunction. One patient lost her smell after an ethmoidectomy. The surgical defect clearly involved the area of the olfactory epithelium. Two others lost their sense of smell following cerebrovascular accidents.

Psychiatric Dysfunction

The last category is psychiatric dysfunction. Three patients were studied. Two had normal smell in one nostril, but had hyposmia in the opposite nostril. One patient had true hyposmia, but also suffered a depressive illness.

Endoscopic Rhinoscopy

Endoscopic findings for all dysfunctions are reported in Table 6. Endoscopy was done with Storz glass rods (often called Hopkins rods). These are optically far superior to the flexible fiber-optic endoscopes. Endoscopy was carried out after phenylephrine (Neo-Synephrine) hydrochloride was administered for decongestion and tetracaine (Pontocaine) was given for anesthesia. The principal observations were that most patients with inflammatory dysfunctions had polyps and other inflammatory changes that prohibited observation of the olfactory epithelium. This is elaborated on in the discussion. With traumatic dysfunctions the dominant observation was that the olfactory epithelium appeared to be absent by visual inspection. Toxins also damaged the olfactory epithelium and, as expected, the olfactory epithelium was absent in the congenital cases seen.

Discussion

One goal with patients complaining of a loss of their sense of smell is to make a diagnosis. If the diagnosis is inflammation, it is possible to improve the condition. If a brain tumor is

discovered, neurosurgical consultation is required. If the loss is congenital or acquired and is permanent, the patient needs a careful explanation and appropriate rehabilitation.

Several observations from this experience are worth noting.

Inflammatory Dysfunction

Inflammatory causes are easily identified. Often a patient complains of a fluctuating loss, which essentially clinches the diagnosis. The majority have abnormal nasal cytology and abnormal CT scans. The most common x-ray film abnormality is opacified cells in the ethmoid sinuses. Generally, inspection of the olfactory epithelium is obstructed by polyps or intranasal mucosal inflammation.

Recovery of the sense of smell on prednisone therapy im-

TABLE 3.—Clinical Features of 20 Patients With Postviral Dysfunction

Age, yr	Mean 60; SD ± 14 ; range 39-89
Male/female ratio	4/16
Olfactory scores	
Right nostril	Mean 36 ± 34 (1 SD); range 0-90
Left nostril	Mean 29 ± 28 (1 SD); range 0-90
Response to steroids	Improved 2; not improved 9
CT scan findings	Abnormal 1; normal 9

CT=computed tomographic, SD=standard deviation

TABLE 4.—Clinical Features of 6 Patients With Traumatic Dysfunction

Age, yr	Mean 33; SD ± 8 ; range 21-42
Male/female ratio	5/1
Olfactory scores	
Right nostril	Mean 10 ± 17 (1 SD); range 0-40
Left nostril	Mean 17 ± 20 (1 SD); range 0-50
Response to steroids	Improved 0; not improved 4
CT scan findings	Abnormal 0; normal 5

CT=computed tomographic, SD=standard deviation

TABLE 5.—Clinical Features of 7 Patients With Toxin Dysfunction

Age, yr	Mean 54; SD ± 12 ; range 34-67
Male/female ratio	3/4
Olfactory scores	
Right nostril	Mean 36 ± 33 (1 SD); range 0-80
Left nostril	Mean 27 ± 30 (1 SD); range 0-80
Response to steroids	Improved 0; not improved 3
CT scan findings	Abnormal 0; normal 5

CT=computed tomographic, SD=standard deviation

TABLE 6.—Endoscopic Observations of Olfactory Epithelium (N=63)

Dysfunction	Normal	White	Absent	Polypoid	Not Seen
Inflammatory	2	0	0	2	17
Postviral	0	13	4	0	3
Trauma	1	0	4	..	1
Toxins	1	2	2	..	1
Congenital	..	..	3	..	..
Miscellaneous	..	..	1	..	2
Psychiatric	..	..	1	..	3

plies there is a potential to smell and appears to be pathognomonic for inflammatory nasal disease.

Viral Dysfunction

Occasionally a viral illness results in a loss of the sense of smell. Whereas men predominated in the inflammatory category cases by a factor of 2 to 1, women exceeded in cases of viral-induced dysfunction by 4 to 1. Some patients reported the loss of smell to be coincident with an upper respiratory tract illness or a flulike syndrome, while others had difficulty making such an association. One notable case was a woman who had a "cold" and lost her sense of smell. Her husband contracted the same "cold" a week or so later and he, too, lost his sense of smell. Rhinomanometry, nasal cytology and CT scans were all essentially normal in the patients with a diagnosis of postviral hyposmia. While nine patients had no response to steroid therapy, two did note a slight improvement. To what degree this represented a concomitant inflammatory condition or some temporary recovery is unclear.

The most interesting observation was seen at nasal endoscopy. The olfactory epithelium was replaced with a white strip of tissue. One physician compared this with the findings in cases of optic atrophy. On closer inspection our impression was that this represented scar tissue and correlated very strongly with a postviral cause. The appearance was definitely different from that seen with traumatic or congenital dysfunctions wherein the olfactory epithelium appeared to be completely missing and replaced by a thin layer of mucosa. Whether this observation was exclusive to or only strongly suggestive of postviral dysfunction is yet unclear. More and more, our impression is that the white scarred tissue strongly suggests a postviral smell disorder.

Traumatic Dysfunction

The traumatic disorders predominated in younger men. Olfactory scores were lower than those seen in patients with the inflammatory and postviral causes. Rhinomanometry, nasal cytology and CT scans were normal. In no cases was a fracture in or near the cribriform plate noted. Endoscopy revealed no tissue resembling olfactory epithelium. The only trauma patient who had any olfactory epithelium was a 28-year-old man with olfactory scores of 40 and 50, indicating moderate hyposmia. At endoscopy the olfactory epithelium was normal, appearing raised and yellow.

Toxin Dysfunction

The cases of toxin-induced dysfunction were fascinating. Some cases were very clear such as one man who purchased a sandwich at a fast-foods market, bit into the sandwich and cracked an ammonia-containing cylinder like those used for arousing fainting patients. He suffered a severe nasopharyngeal and intranasal burn, lost his sense of smell and never regained it. Olfactory scores averaged around 30, but there was a large standard deviation, ranging from 0 to 80. Rhinomanometry and nasal cytology were normal. CT scans were also normal, and none of these patients reported improvement on prednisone therapy. Endoscopic findings were significant. In two patients, no olfactory epithelium was observed. Two patients had the white scarring seen with postviral dysfunction. Whether these represented postviral dysfunctions or an alternate method of scarring is difficult to say. If the white appearance was indeed scar tissue, toxic destruction would be consistent with such findings. One man with olfactory scores of 70 to 80, with heavy exposure to acetone and a history of

smoking five to six cigars a day, had normal-appearing olfactory epithelium. Another person exposed to photodeveloping chemicals and with scores of 60 and 80 had a yellow, flattened epithelium with areas of scarring across it.

Congenital Dysfunction

The cases of congenital losses were straightforward. Olfactory scores in all three patients were 0 in both nostrils. In all cases the olfactory epithelium appeared to be absent and replaced by a thin mucosa. Rhinomanometry, nasal cytology and CT scans were normal. Most interesting was their history. These patients had never smelled and hence did not consider it a major dysfunction. Food was attractive to them and they tended to focus on sensations such as salt, sweet, sour, bitter, temperature and feel. This was in strong contrast to those whose chemosensory loss occurred later in life. For those patients the loss of smell was a major loss. This was particularly so for persons for whom cooking was a major part of their lives. One woman's tearful description of not being able to smell her own Christmas dinner was frankly tragic. Some patients lost their appetite and lost weight. Others reported eating too much, hoping with each bite for some "taste" to come through.

Discussing the loss of the sense of smell has been greatly hampered by the English language. The major chemosensory input from food is smell. This is most commonly called taste, but has little to do with the chemosensory tastes of sweet, sour, bitter and salt. It would be better if food were described differently. Certainly it has a characteristic appearance. Often we discuss its temperature and occasionally we note its lack or excess of sweet, sour, bitter or salt. We seldom note this if all is well. We only note aroma if the food is still on the plate and almost never take a bite and exclaim that the food smells great. For purposes of discussion in the clinic, we refer to the overall gestalt of food as its flavor and reserve the word taste for the four known tastes.

Miscellaneous Dysfunction

The miscellaneous category included one patient who clearly lost her sense of smell after an intranasal ethmoidectomy. Nasal endoscopy confirmed that the surgeon had operated medial to the attachment of the middle turbinate bilaterally and had removed virtually all of the olfactory epithelium.

The other two patients appear to have lost their sense of smell following cerebrovascular accidents. This was difficult to confirm. One had abnormal ethmoid sinuses on CT scan, but as he did not respond to antibiotic or prednisone therapy, he did not belong in the inflammatory category. Various drugs have allegedly interfered with the sense of smell. Both patients had taken a variety of medicines, and perhaps this offers an alternate cause.

Psychiatric Dysfunction

The last category is psychiatric. One patient had olfactory scores of 100 and 60, the other 80 and 100. The remainder of their evaluation was normal and certainly both had significant psychiatric difficulties. The third patient was depressed, associated with retirement and a major financial error and loss. His olfactory scores were 20 and 30, and the remainder of his evaluation was normal. Psychotherapy partially resolved his depression, but did not subjectively alter his sense of smell. One patient in this category with normal smell did not have olfactory-looking epithelium at endoscopy. Given the normal olfactory scores, this was most likely an inadequate examina-

tion. There is a definite decrease in the olfactory threshold with age. The olfactory scores are corrected for this, but this patient represents an extreme of this phenomenon, which we refer to as presbyosmia.

In this overall series of 63 patients, none identified any benefit from zinc sulfate therapy. Two patients whose workups were not complete and therefore were not included in the study did report by telephone that they felt better after taking zinc. To what degree this represented improved olfaction and to what degree the improvement was related solely to other effects of zinc is undetermined.

Anosmia has received far less attention than have other sensory defects such as blindness and deafness. Hence, little has been done in the field of rehabilitation. The most worrisome problems are the inability to smell smoke, gas or spoiled food. Patients are advised to place smoke detectors in the kitchen, by the fireplace, near all other places where fire might occur and in all rooms in which they nap or sleep.

They are advised not to keep gasoline in the garage or in sheds and certainly never to light a match wherever there might be gas. For those using propane or natural gas, industrial grade gas detectors are recommended. Propane gas and gasoline are heavier than air so the detectors must be mounted at floor level. Natural gas is lighter than air and requires ceiling-mounted gas sensors. The best referral source for gas detectors is a marine electronics store because various gas detectors are used in most larger boats.

Persons with anosmia are unable to detect spoiled food. If they live with other people they should *always* ask someone with a normal sense of smell to sniff leftovers and other foods likely to be spoiled. If they live alone, they must develop a rigid program for discarding leftover food.

The most difficult problem for these persons is rehabilitating their eating pleasures. Attention must be diverted from smell to the other senses. Appearance, temperature, texture and taste must be highlighted. Many patients have been able to season with nasal and oral trigeminal stimulants. These include horseradish, capsicum, mustard, ginger, clove, cinnamon, peppermint, spearmint, pepper and pimento. Mexican foods and Indian dishes are often appreciated for their spices and hot sauces, which are stimulating.

Salt ideally should not become a desired taste because these persons might consume it heavily. Also, for those finding themselves overindulging in search of flavor, weight control must be taught.

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